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COMBUSTION OF FOSSIL FUELS IN
BANGLADESH**

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AN ANALYSIS OF CO₂ EMISSION FROM COMBUSTION OF FOSSIL FUELS IN BANGLADESH

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Abstract:

Carbon-di-oxide (CO₂) is one of the most important gases in atmosphere, which is necessary for sustaining life cycle in earth. It is also considered as the major green house gas contributing to global warming and climate change. In this study, the energy consumption structure in Bangladesh has been analyzed and CO₂ emission from fossil fuel (coal, gas, petroleum products) combustion has been estimated from 1977 to 1995. The IPCC (International Panel for Climate Change) Guidelines for National Greenhouse Gas Inventories were followed in CO₂ emission estimation. First, annual energy consumption is multiplied by net carbon emission factor for fuel type to obtain net carbon emission. Then actual carbon emission is estimated from net carbon emission and it is converted into CO₂ emission.

The estimated total CO₂ release from all primary fossil fuels use in Bangladesh amounted to 5072 Gg in 1977, which increased to 14423 Gg in 1995. Total amount of CO₂ release from petroleum products, natural gas and coal in the period 1977 to 1995 were 83026 Gg (50%), 72541 Gg (44%) and 9545 Gg (6%), respectively. An emission trend of CO₂ with projection up to 2070 is generated. In 2070 total estimated CO₂ emission will be 293260 Gg with current growth rate of 6.34% per year. It is observed from the estimated results that CO₂ emission from fossil fuels shows an increasing trend. Petroleum products contribute most in CO₂ emission load. Though the use of Natural gas is increasing in a rapid rate its contribution to CO₂ emission is less than petroleum products. The use of coal as well as the emission from it decreases gradually. This study will give useful information on Bangladesh's contribution to global level greenhouse gas emission as well as planning and decision taking processes regarding global warming, climate change and sea level rise.

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KEYWORDS:

Fossil fuel, combustion, carbon-di-oxide, emission, greenhouse gas.

INTRODUCTION:

Carbon-di-oxide (CO₂) is one of the most important elements of the atmosphere. The natural emissions of CO₂ from living animals, human, wetlands, volcanoes etc are perfectly balanced by the same amount being removed from atmosphere by plants photosynthesis and by the oceans. Human activity, on the other hand, is disturbing this equilibrium by generating increased CO₂ from fossil fuels, i.e., coal, gas and petroleum products, combustion in electricity generation, transportation, industry and domestic use. The results of these imbalances are greenhouse effects, global warming, melting of polar ice sheets and caps, sea-level rise and subsequent coastal inundations, damage of agriculture and natural ecosystem etc. Therefore, it is very important to study the CO₂ emission from human activity in a developing country like Bangladesh, which is not a great contributor of CO₂ but is highly vulnerable to its adverse effect.

Very limited studies have been conducted on CO₂ emission in Bangladesh. Department of Environment (DOE) performed a study on CO₂ release in Bangladesh for only one particular year 1990(MOEF, 1997).In this article, an attempt has been made to analyze the fossil fuel consumption pattern and trends of Bangladesh. The pattern and trends of CO₂ emission due to combustion of fossil fuels have also been investigated.

MATERIAL AND METHODOLOGY:**STUDY AREA:**

The area selected for estimating CO₂ emission from fossil fuels is Bangladesh (Figure 1). It is a south Asian country located between 20.34° and 26.38° north latitude and between 88.01° and 92.12° east longitude with an area of 147,570 sq.km and a population of 119.8 million (BBS, 1996). It has a humid, warm tropical climate that is fairly uniform throughout the country. Maximum temperatures ranges between 20°C and 40°C and minimum average just above 10°C.Humidity ranges between 63% to 90% and precipitation range is 1100mm/annum to 5690mm/annum.Forest area covering the country is about 9%.The topographical height is only few meters above mean sea level. The country is subjected to devastating cyclones, water surges and floods frequently.

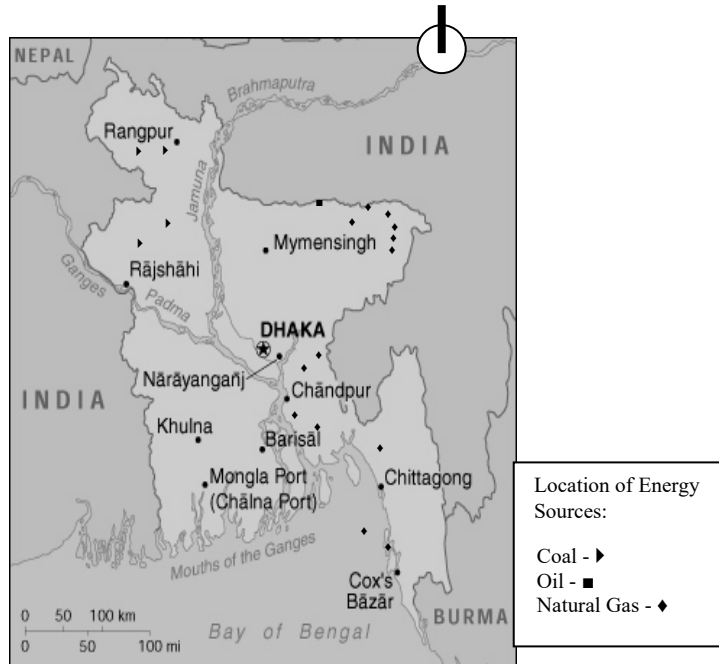


Figure1: Study area, Bangladesh.

STRUCTURE OF ENERGY SYSTEM IN BANGLADESH:

Energy is a crucial input for economic development and for improving the quality of life. Energy resources in Bangladesh comprise of commercial resources and biomass resources. Only about 37% of the needs of energy are met by commercial energy (Bala, 1998); the remaining needs, mostly in rural areas of Bangladesh are met by biomass fuels. The primary commercial energy resources in Bangladesh include natural gas, petroleum products, coal, and hydro-electricity.

In Bangladesh biomass fuels are fuel woods, agricultural residue and animal dung. Land is the ultimate resource base for biomass production. The large source is crop land and it supplies 60.20% of biomass fuel while livestock is the second and it supplies 16.21 of biomass fuel (Bala, 1998).

The overall energy situations in Bangladesh in 1977 and in 1995 are summarized in Table 1 and Table 2, respectively. Here all energy supplied are expressed in the form of a common energy unit petajoules, PJ or 10^{15} joules. Table 1 shows that petroleum was used extensively as commercial fuel. The total

energy supplied in 1977 was 75.69 PJ, of them 22.53 PJ is supplied from natural gas, 45.53 PJ from petroleum products and 7.59 PJ from coal.

From Table 2 we see that natural gas was the biggest source of energy used; use of coal decreased that year. The total energy supplied in 1995 amounted to 237.32 PJ, of them 138.38 PJ was supplied from natural gas and 98.94 PJ from petroleum products. So, there was an increase in the use of natural gas and decrease in the use of coal and petroleum products in 1995 from the year 1977.

Consumption patterns of different fossil fuels in year 1977 and 1995 are shown in Figure 2 and in Figure 3, respectively.

Table 1: The energy balance of Bangladesh (1977)

Description	Natural gas (PJ)	Petroleum Product(PJ)	Coal (PJ)	Total (PJ)
Primary production	35.34	-	-	35.34
Flare and loss	-	-	-	-
Imports	-	12.19	7.17	20.36
Exports	-	8.44	-	8.44
Bankers	-	-	-	-
Stock exchange	-	1.90	0.42	2.32
Refineries	-	48.74	-	48.74
Power station				
- hydro	-	6.01	-	-
- thermal	11.71	-	-	17.72
losses and own use	1.10	-	-	1.10
Net energy available	22.53	45.58	7.59	75.69
Residential	0.84	15.72	-	16.56
Commercial	0.42	9.40	-	9.82
Industrial	4.64	2.63	7.5	14.78
Transport	-	15.83	-	15.83
Other energy use	-	2.0	-	2.0
Non-energy use	16.70	-	-	16.70

Source: Bangladesh Bureau of Statistics(1980)

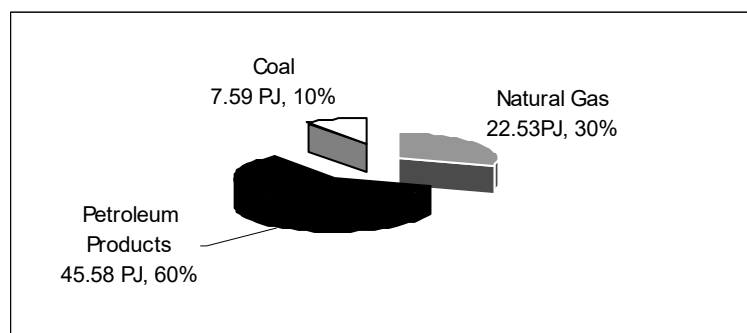


Figure 2: Consumption of fossil fuels in Bangladesh (1977)

Table 2: The energy balance of Bangladesh (1995)

Description	Natural gas (PJ)	Petroleum Product (PJ)	Coal (PJ)	Total (PJ)
Primary Production	270.39	-	-	270.39
Imports	-	53.64	-	53.64
Export	-	-7.23	-	-7.23
Bankers	-	-1.65	-	-1.65
Stock exchange	-	-2.07	-	2.07
Statistical difference	-	0.74	-	0.74
Oil refining	-	63.17	-	63.17
Gas manufacture	-	-	-	-
Fuel input	-117.46	-11.78	-	-129.24
Power generated	-	-	-	-
Transmission and distribution loss	-14.35	-	-	14.36
Own use and loss	-0.19	-	-	0.19
Net energy available	138.38	98.94	-	237.32
Residential	19.88	19.98	-	-39.86
Commercial	4.02	-	-	4.02
Industrial	26.56	6.95	-	33.51
Transport	-	52.49	-	52.49
Agriculture	-	19.52	-	19.52
Non-energy use	87.93	-	-	87.93

Source: Bangladesh Bureau of Statistics (1997)

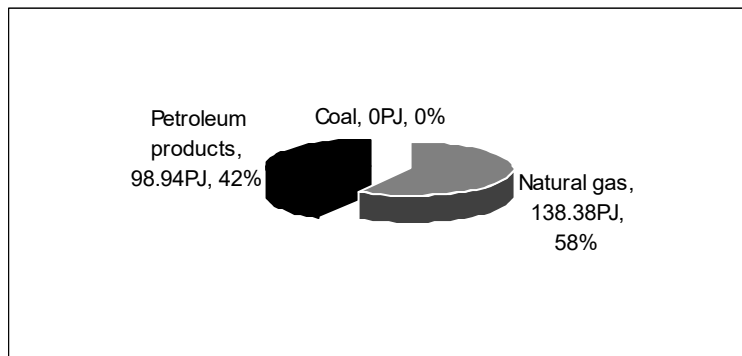


Figure 3: Consumption of fossil fuels in Bangladesh (1995)

Consumption patterns of different fossil fuels from 1977 to 1995 are shown in Figure 4. As can be seen, the proportion of fossil fuels is gradually increasing. This is mainly due to the increase use of natural gas, which has grown from 25% in 1977 to more than 67% in 1995 of the fossil fuel requirement. The use of imported oil has been restricted to only those uses that can not or difficult to be met by natural gas. From this Figure it is seen that use of coal becomes zero in 1995.

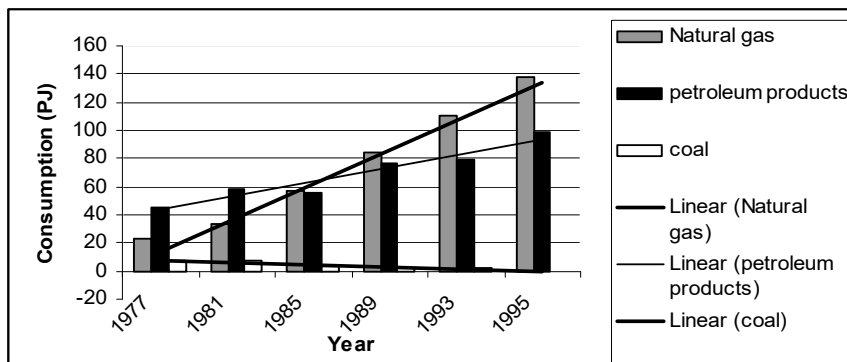


Figure 4: Consumption of different fossil fuels from 1977 to 1995

Commercial energy consumption in Bangladesh is growing at a rapid rate (>5% per year). With population growth and economic development, energy consumption will increase further. A shortfall in the supply of biomass will also results in increased consumption of commercial energy. The most visible effect of economic development will be the gradual replacement of biomass fuels by fossil fuels. The factor that will affect future emissions the most, is the availability of natural gas.

METHODOLOGY FOR EMISSION ESTIMATION:

Since biomass burning does not contribute much to the CO₂ emission load (IPCC, 1996) only fossil fuel use is considered for the estimation of CO₂ emission in this study. The steps involved for the estimation of CO₂ from fossil fuel combustion are described below:

Step-1: Annual fuel consumption was calculated using the identity:
Total supply = production + Import – export – stock change.

Step-2: The apparent consumption (Net Primary Energy) was multiplied by heat values of the respective fuel types to convert them to energy units (Terajoules or 10¹² Joules) (IPCC, 1994).

Step-3: Apparent consumption figures are multiplied by fuel specific carbon emission factors to estimate net carbon content of each fuel type. Default carbon emission factors for each fuel type are taken from IPCC (1994).

Step-4: Net carbon emission is estimated by subtracting carbon stored from net carbon content. IPCC (1994) manual is used to estimate carbon stored. Values for fraction of carbon stored for each fuel type is given in the same source.

Step-5: Actual carbon emission was estimated by multiplying net carbon emission with fraction of carbon oxidized. This step is aimed at correcting emission values for incomplete combustion.

Step-6: The corrected value of oxidized carbon is then converted into CO₂ emission by multiplying by the stoichiometric factor (44/12), i.e., molecular/atomic ratio of CO₂ to carbon.

RESULTS AND DISCUSSION:

Emission estimation for the base year 1995 is given in Table 3. Petroleum products include high speed diesel, kerosene, furnace oil, motor spirit etc. There was no use of coal in this year. For each type of fuel, different carbon factors are used which are obtained from IPCC guidelines (1994).

The total carbon-di-oxide release from all primary fossil fuel use in Bangladesh amounted to 14,423.49 Gg in 1995. The corresponding quantity of carbon (in oxidized form) is 396.72 Gg. In 1977 CO₂ emission was 5071.89 Gg due to combustion of petroleum products, natural gas and coal. There is a large increase in CO₂ production between the year 1977 to 1995 (Figure 5).

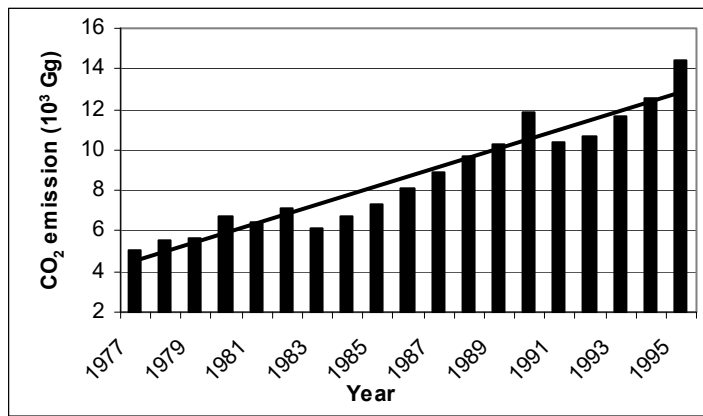


Figure 5: CO₂ emission from the year 1977 to 1995

Figures 6, 7 and 8 show the trends of CO₂ emission from natural gas, coal and petroleum, respectively. From figure 6 it is found that CO₂ emission from natural gas shows an increasing trend in a rapid scale. This is because the use of natural gas was rapidly increasing from 1977 to 1995 due to its availability, easy handling and transport, easy to use, low cost etc. Use of natural gas in Bangladesh is growing in different sectors such as fertilizer industries, electricity generation, cooking, traffic vehicles etc.

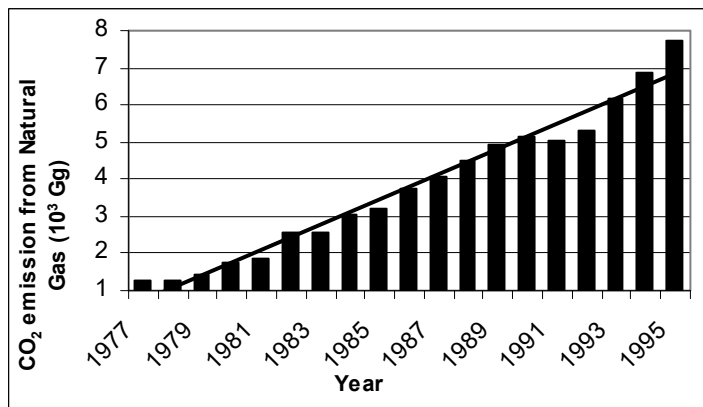


Figure 6: CO₂ emission from combustion of natural gas (1977-1995)

Table 3: CO₂ emissions from primary energy consumption in Bangladesh in 1995

Primary energy sources	Energy consumption (PJ)	Carbon emission factor* (10 ³ tC/PJ)	Net carbon emission (Gg)	Fraction of Carbon	Total CO ₂ emitted (Gg)
Natural gas	138.38	15.3	2117.21	0.995	7724.29
Petroleum products	98.94		1845.51	0.990	6699.20
High speed diesel	49.47	19.5	964.67		
Kerosene	24.04	19.6	471.18		
Furnace oil	7.92	20.2	159.98		
Motor spirit	102.17	17.2	102.17		
Jet propellant	4.95	19.5	96.53		
Jute batching oil	2.0	21.1	42.2		
Others	4.62	1.9	8.78		
Coal	0.0	26.8	0.0	0.980	0.0
Total					14423.49

* Carbon emission factors for different fuel types and corresponding values for fraction of carbon oxidized are obtained from IPCC guidelines (IPCC, 1994).

Figure 7 shows the amounts of CO₂ emission from coal. This figure indicates a slight increase in CO₂ emission upto 1982 and then a decreasing trend. In 1995 there was no use of coal. The reasons of this decreasing trend are the increasing use of natural gas and petroleum products.

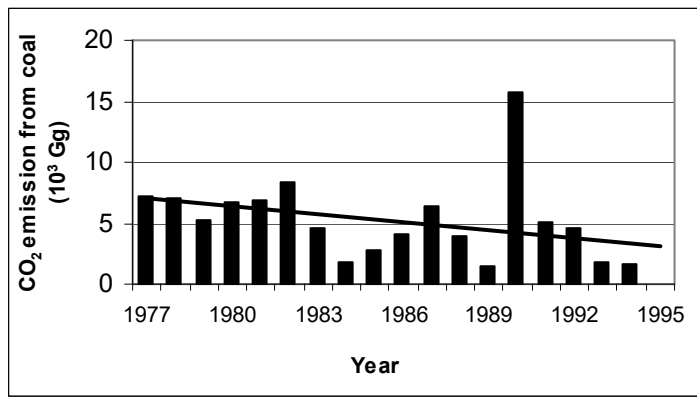


Figure 7: CO₂ emission from combustion of coal (1977-1995)

Figure 8 shows CO₂ emission from petroleum products, for example high speed diesel, kerosene, motor spirit, jet propellant etc and depicts an increasing trend of CO₂ emission. There is a little fluctuation in CO₂ emission depending upon consumption of petroleum products. There is almost no petroleum field in our country, people largely depends upon import of it. The use of petroleum is currently being replaced by the use of natural gas.

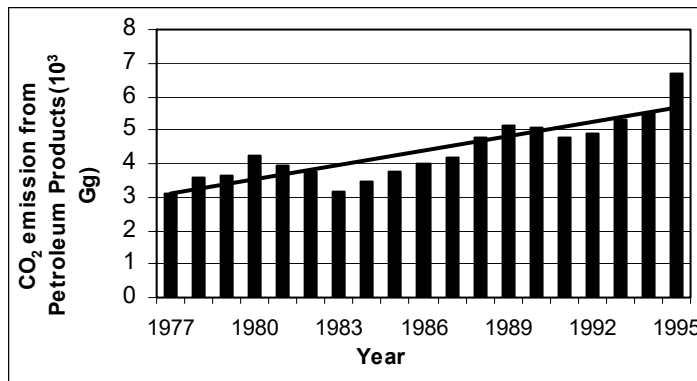


Figure 8: CO₂ emission from combustion of petroleum products (1977-1995)

Figure 9 shows the contributions of natural gas, petroleum products and coal in total CO₂ emission from the year 1977 to 1995. Though CO₂ emission from natural gas shows a sharp increase in figure 5, petroleum products contribute mostly in CO₂ emission; 50% of total emission. Then natural gas contributes 44% and coal 6% of total CO₂ emission from fossil fuels.

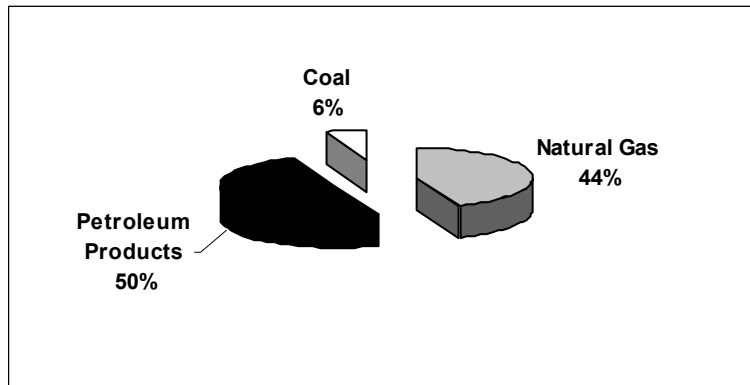


Figure 9: Contribution (%) of fossil fuels to CO₂ emission (1977-1995)

A future emission trend for CO₂ is shown in Figure 10, which was generated on the basis of average emission rate of CO₂ from 1977 to 1995. Due to increased industrialization and economic development, the use of commercial fuels in Bangladesh will be increasing sharply, and as a result the amount of CO₂ emission will increase rapidly.

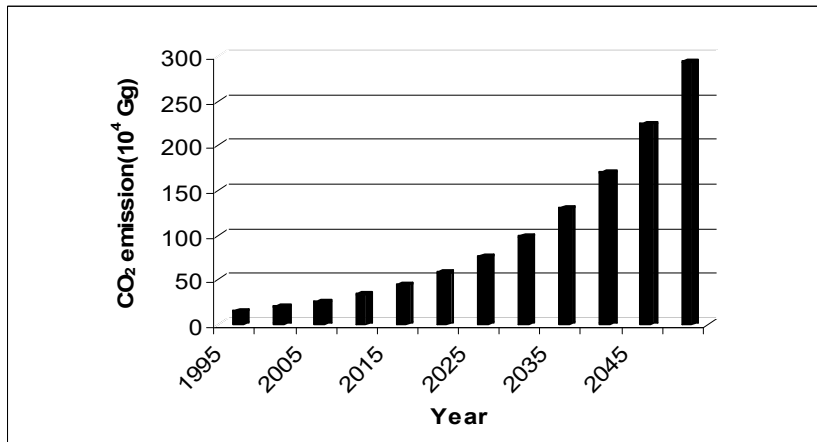


Figure 10: Future trend of CO₂ emission (1995-2070)

Limited data are available to compare with the estimated CO₂ emission of this study. DOE estimated CO₂ emission from commercial fuels in Bangladesh which was 13,442 Gg for 1990 (MOEF, 1997). This value compares well with the estimated value of CO₂ in this study which was 11,816 Gg for the same year.

CONCLUSION:

In this study, the energy structure and CO₂ emission scenarios of Bangladesh are analyzed in detail. With respect to carbon contents of fuels as a basis for an estimate of the amount of the CO₂ emission, the data and information are obtained from Bangladesh bureau of statistics, bureau of energy department etc. CO₂ emission factors are taken from IPCC(1994). On the basis of these results, the amounts of CO₂ emission from fossil fuels are calculated. The results of the study could be summarized as follows:

- i) The consumption of fossil fuels in Bangladesh is growing at a rapid rate (>5% per year). There was an increase in the use of natural gas and a decrease in the use of coal and petroleum products in the period 1977 to 1995.
- ii) The total carbon-di-oxide release from all primary fossil fuels use in Bangladesh amounted to 5072 Gg in 1977, which increased to 14,423.49 Gg in 1995 having a growth rate of 6.345 per year.
- iii) From emission figures for each fossil fuel it is found that natural gas shows a sharp increasing trend, coal shows a decreasing trend and petroleum products show a slow increasing trend of CO₂ emission.
- iv) The primary source of CO₂ is petroleum products which contributed 50%; followed by natural gas whose contribution was 44% in total CO₂ emission during 1977 to 1995.

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